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USP
THE UNIVERSITY OF THE SOUTH PACIFIC

Nursery Tool Kit

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1.INTRODUCTION

Background

This toolkit is the result of a regional workshop on nursery management, held in Port Vila, Vanuatu at the Emalus Campus of the University of the South Pacific in April of 2007. It was also decided that a guide in the form of a toolkit for farmers and other stakeholders should be developed to assist them in their vegetable nursery work and nursery management.

Contributions to this toolkit?

The information gathered from the participants in the regional workshop on vegetable nursery management that was held in Vanuatu in April of 2007 is used in this toolkit. The participants were from various backgrounds ranging from, vegetable growers to vegetable exporters, school principals and extension officers.

The need for this toolkit

The need for growing vegetables has grown in intensity with the advance of the tourism industry in the Pacific region and the changes in dietary habits of the people. This calls for increased production of quality vegetable seedlings. However, because of the high costs of good quality seeds and nursery material in general, it was decided at the first workshop in 2001 that a toolkit should be developed to guide farmers and people involved with rural communities to produce seedlings in a more cost effective way. A regional workshop on Vegetable Nursery Management in Vanuatu in April 2007 was used to compile information from around the Pacific Island Countries to include in this toolkit.

Users of the toolkit

This toolkit is intended for the use of vegetable growers and those who work with the farming community such as teachers, womens' committees and extension officers.

How to use this toolkit

This toolkit is expected to provide practical guide for vegetable nurseries workers and as a reference manual for extension and training. By following instructions and guides in this toolkit, the user is assured of excellent results.

2. PLANNING A VEGETABLE NURSERY

What is a vegetable nursery?
A vegetable nursery is a place where vegetable seeds are sown to germinate and the resulting seedlings are cared for until they reach the size when they are transplanted out to their permanent growing positions in the field.

Why is a nursery important for vegetable seedlings?
A nursery provides protection to the seedlings from:

- pests
- diseases
- heavy rain
- sun and against extreme temperatures

Setting nursery objectives.
Now you know the functions of a nursery and why it is necessary. The next question you should answer is who are you going to grow the seedlings for? Is it for your own vegetable production in your garden or is it to supply other vegetable farmers? If it is for the latter then it is more of a commercial nursery. This would mean it is going to be planned and run slightly differently than if it was for your own vegetable seedling production. The size of the nursery would also need to be bigger since you would be producing seedlings for other people as well as for your own.

The above are very important questions to answer because the objectives or targets of a vegetable nursery; namely, how many seedlings you should produce and how often you should produce them, are based on this information. So before making the nursery you should have the following information and make decisions before setting nursery targets.

1. **Market demand:** are you going to produce seedlings for you own vegetable production or are you going to produce seedlings for others?
2. **Amount of capital on hand:** Would you have enough money to build the nursery that would satisfy your seedling requirements or would you need to borrow funds? If you need to borrow money there are

Development Banks that are able to lend you money. In other countries of the region the Ministry of Agriculture offer assistance. It is therefore recommended to consult your local Mministry of Agriculture during planning to find out what assistance they can provide.

3. **Make sure the land is secure**, by making an agreement with the land owner if the land is not yours.

What are some characteristics of an ideal location for a nursery?

- Near home or farm house for ease of operation and proper management.
- Near a good and reliable water supply.
- Near wind brakes. These can be natural vegetation such as hedges around the nursery. If required, physical barriers should be put up around the sides of the nursery shelter to protect seedlings from wind.
- Accessible to enable good transport to planting area.
- An area with plenty of sunlight. The nursery should be oriented North- South to ensure prolonged exposure to sunlight.
- In atolls the nursery should be located inland to protect from sea spray. If this is not possible then the nursery should be protected from sea spray by putting up walls around the nursery shelter.

3. TYPES OF VEGETABLE NURSERY DESIGNS SUITABLE FOR PACIFIC ISLAND COUNTRIES

What are suitable vegetable nursery designs for South Pacific Countries?

a) Raised Seedbed Nursery Design.

Which vegetable growers is a raised seedbed nursery suited for?

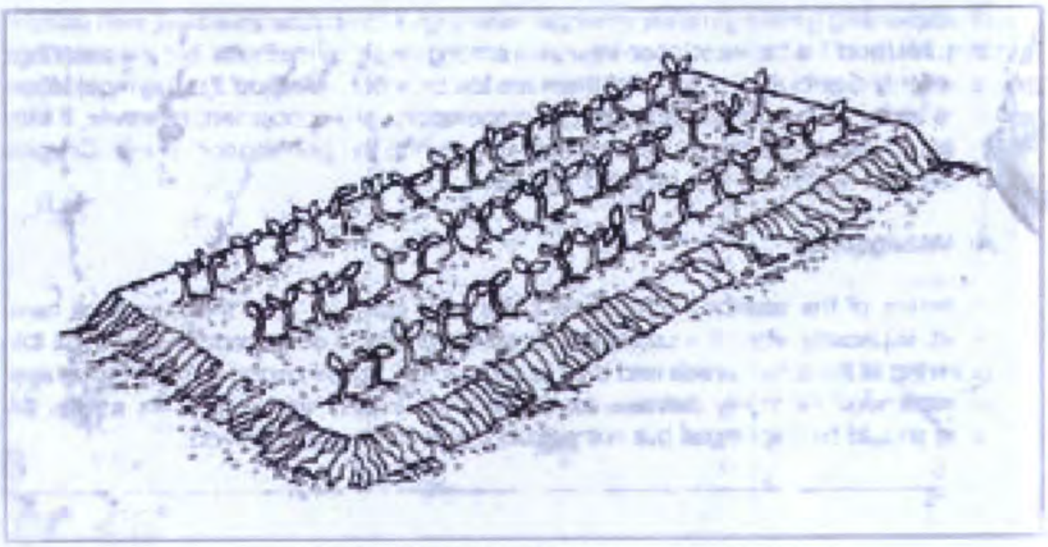
* Schools, for students garden plots.
* A backyard gardener who grows vegetables for home consumption.
* A semi-commercial vegetable grower who sells some of the produce in the local market.

What are the components of a raised bed nursery?

- a raised bed in which seeds are sown
- a temporary shelter to protect the seedlings from rain, direct sunlight and extreme temperatures.

Seed bed

- The size of a seedbed nursery depends on the size of the area to be planted and how often vegetable crops are to be planted. In the case of a school or a commercial grower where large numbers of seedlings are required several seedbeds may be planted and for a backyard gardener whose seedling requirement is much less, maybe one seedbed would be enough.



Seedbed for sowing seeds

How to construct a raised seedbed nursery

a. Clear site of shrubs and weeds.

b. Level the area.

c. Mark out nursery area, the size depending on the number of seedlings to produce

d. Measure out seedbed area of 1 to 1.5 meters wide and the length determined by the number of seedlings required and shelter material available to the farmer.

e. Turn the soil using a garden folk to loosen the soil.

f. Level the soil with a garden rake to remove small rocks and form the bed.

g. If manure is available mix the manure in and again use the rake to level and remove any more stones.

h. Build a temporary shelter as shown in the picture below. It should be about 2 meters high.

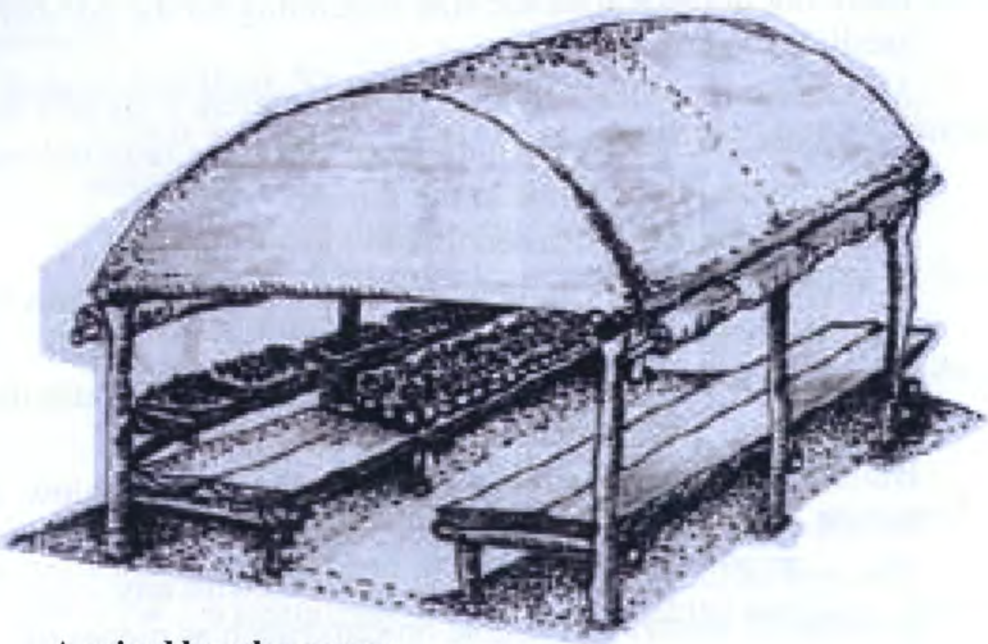
i. The roof of the shelter is usually covered with any transparent material available on-hand such as pieces of hard plastic and plastic films or coconut fronds.

j. The sides of the structure are also covered with coconut fronds. More resourceful farmers may erect a simple fence of pig or chicken wire-mesh around the seedbed for protection.

A seedbed nursery with a roof of hard plastic and sides covered with coconut fronds. The walls of coconut fronds have been thinned out to allow more sunlight into the nursery. A fence of pig wire mesh protects the nursery from animals.

b) Raised Bench Nursery

The raised bench nursery consists of a portable shelter with hip high benches for seedling trays or other kinds of seedling containers.



A raised bench nursery

How to construct raised bench nursery.

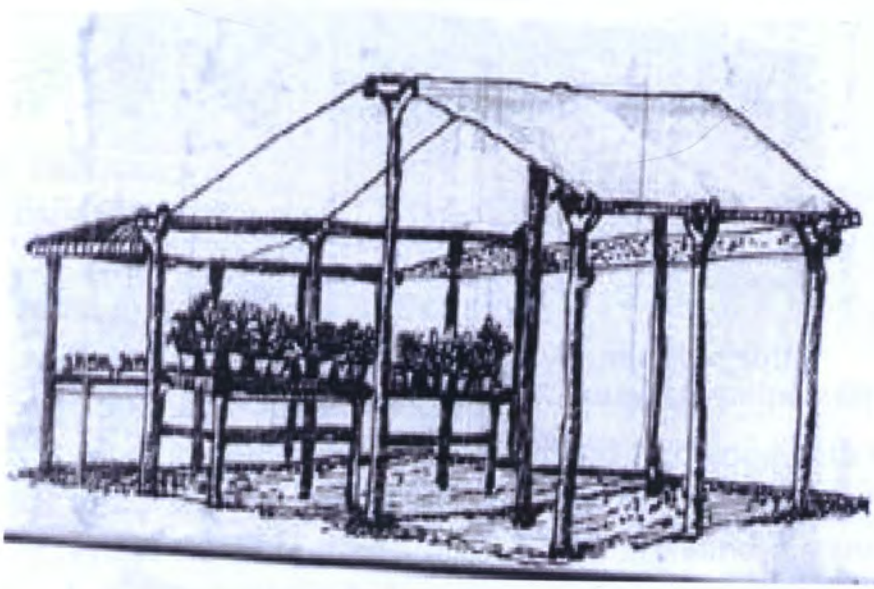
a. Clear site of shrubs and weeds.
b. Level the area.
c. Mark out nursery area.
d. Dig holes and place in posts. Posts can be from local trees like bamboo.
e. Assemble roof structure components.
f. Measure and cut out branches/timber to construct benches (preferably hip high) and the size according to nursery operations.
g. Make the benches or shelves using nails or strings.
h. Surround nursery shelter with plastic or coconut fronds for wind protection if hedges are not available.

c) Shade houses.

Shade houses work on the same principle as the seedbed nursery and that is to provide protection for plants from direct sunlight and some protection from heavy rain since the covering material provides shade for plants and is permeable to water. Such roofing materials include nylon netting and sarlon shade cloth that provide different degrees of shading. Seedlings and newly grafted plants should be kept, depending on the species, in 30 to 70% shade. Simple shade houses are built of wood and twigs and usually have flat roofs covered with suitable shade material, example, shading net.

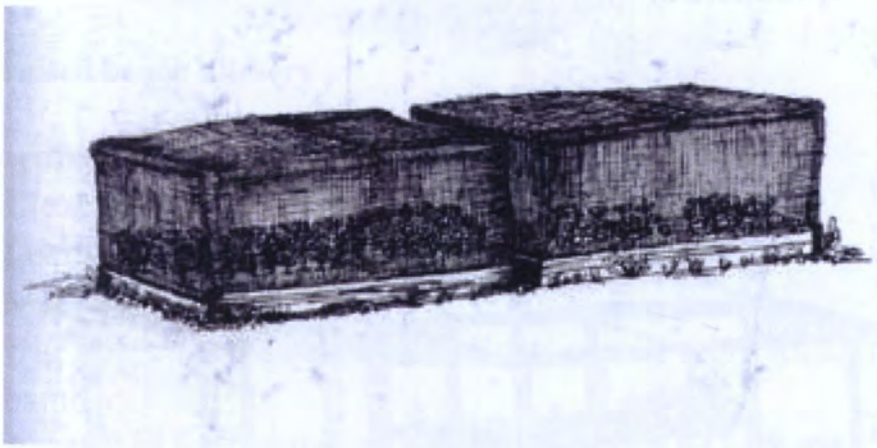
How to construct a simple shade house.

- The sizes of shade houses normally depend on the scale of operation and resources available to the farmer.
- These structures range from simple shade material stretched horizontally between four posts to large wooden frames mounted horizontally on top of steel or wooden posts.
- The roof and sides of shade houses are normally covered with the shading material and irrigation can be provided manually with watering cans and hoses or by overhead sprinklers or misting systems.

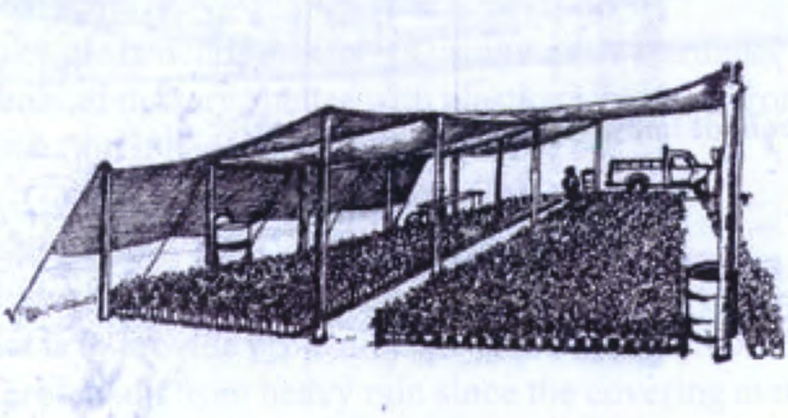


A simple shade house made of wood.

A nylon material is stretched out above the crop to provide shading.

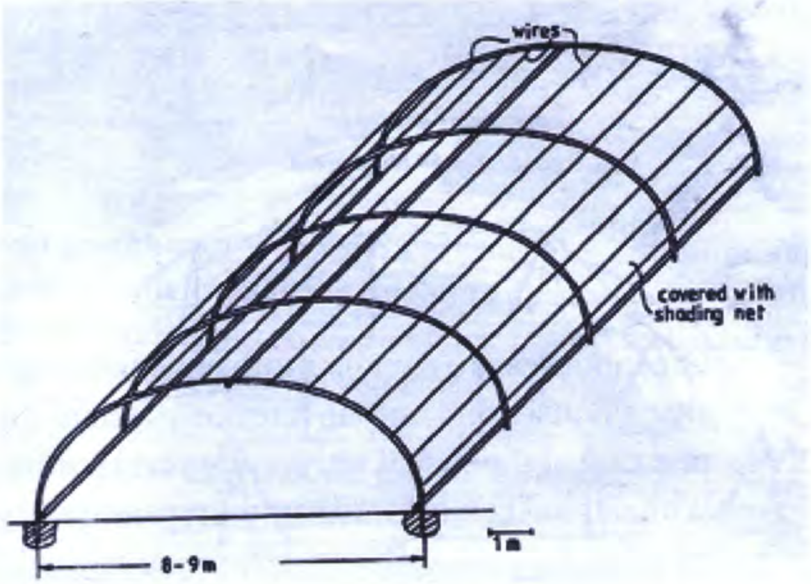


Small shading structure for vegetables.



A large forestry nursery with shading material mounted on steel pipes. Notice that the seedlings are growing in plastic bags

Tunnel Shade Houses.
For small areas, especially nurseries, tunnels are used as shade houses. These are composed of arched steel tubes. Wires are attached to the framework longitudinally and shading nets are put over the wires and fastened.These are suitable for areas with strong winds,example cyclones

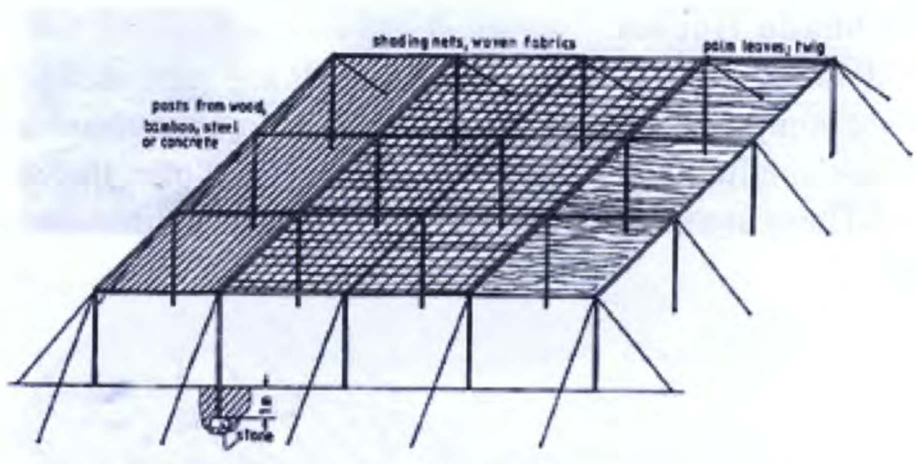


Tunnel shade

Shading Halls.
Shading halls are appropriate for large areas .

How to construct Shading Halls.

- Wooden bamboo posts are driven into the soil.
- Upper ends are connected by wire ropes. To stabilize the structure, outer posts are fixed and tightened with sloped ropes and anchors.
- These shade houses are 2.5 to 4m high and distance between posts is 4x4m.
- Shading nets are stretched on the upper horizontal surface of shade houses.
- In Kiribati, the nets also cover the sides of the shade house and a 'door' made for access into the nursery.
- In addition, a fence of chicken wire is built around the shade house. Vegetable seedlings are raised in washed beach sand put in cleaned half 44 gallon drums cut lengthwise with drainage holes at the bottom. These are raised above the ground on supports of bricks.



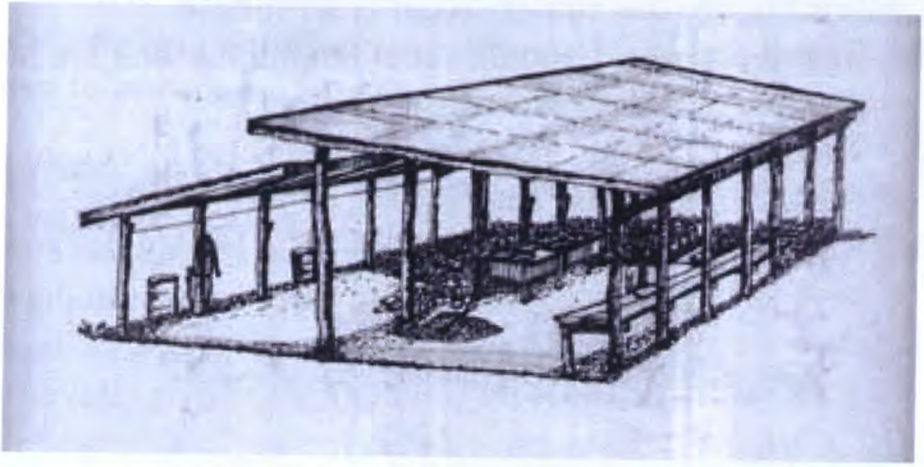
A shading hall

d) Greenhouses

- Greenhouses are usually more expensive to build than shade houses and only institutions such as government research stations and universities and commercial farmers with capital can afford them.
- Greenhouses range from highly sophisticated structures equipped with mechanisms for control of the greenhouse environment to more affordable simple structures.
- Greenhouses normally have roofs that are impermeable to water and they protect the seedlings and crops, which are grown in containers from rain. However, cover materials that both provide shade and are impermeable to water are now available.
- The roofs of greenhouses are sloped so that rain can flow off. The covering material is of plastic film for cheaper greenhouses and glass or rigid plastic for more expensive ones.
- Irrigation in greenhouses is by the use of watering cans or with over-head sprinkler or misting systems. A drip irrigation system maybe used in greenhouses for protected cultivation.

What are the two types of green houses?

1. **Structures with permanent open ventilators** and large volume for good air circulation are recommended for tropical wet and dry climates.
2. Structures with closable ventillators for sub tropica lhumid climate andfordry areas

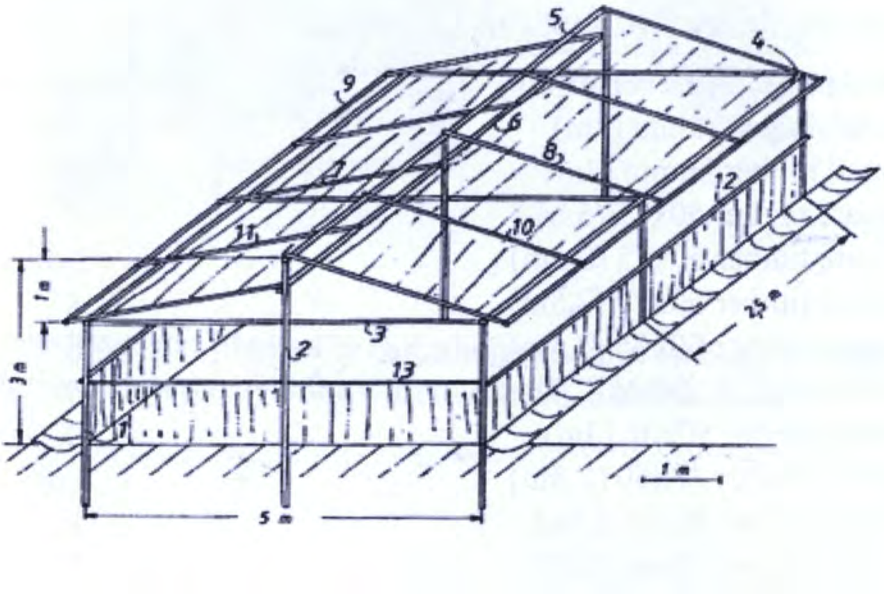


A low cost greenhouse with roof covering of plastic film and permanent ventilators on the ridge and open sides for ventilation. Greenhouse of this type is recommended for protected cultivation of vegetables in the wet and dry tropics.

Construction of selected types of green houses.

1. Simple single span green house.

The simple single span construction is recommended for Pacific Island Countries (PICs) since good ventilation is required in tropical humid climates. The construction should have measures to improve ventilation efficiency, example, large volume/ground ratio if wind speed is not too high, open sidewalls, gables and ridge ventilators, nets at ventilators when necessary. A simple single span construction that can be used in the introductory stage of vegetable production is shown below.



Simple single-span construction.Source:Von Zabeltitz and Baudoin,1999

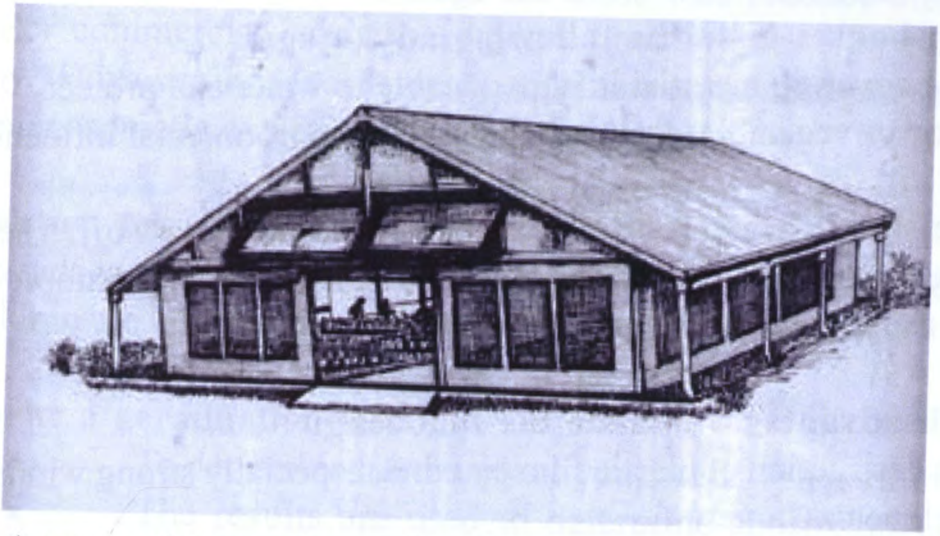
The assembly of the construction is as follow.

1. Round timbers (1 and 2), about 80mm diameter are buried as posts, 1m deep into the soil.
2. The upper ends of the posts are connected by square timber (3, 4 and 5) lengthwise and crosswise.
3. A second square timber (6) is attached lengthwise on the middle post, so that a free ventilation opening remains at the ridge.
4. Over the stanchions, as a roof construction, round timbers (7 and 8) are nailed onto the longitudinal rods and linked with round timbers (9) at the lower end.
5. On each side of the roof, a section of film is placed on this roof construction, drawn tightly in a longitudinal direction, and fastened on the gable ends by nailing it firmly with battens.
6. Round timbers (10 and 11) are put and fastened in the middle between the stanchions for stretching and holding the film.
7. At the sidewalls and gables, round timbers (12 and 13) or wires and film is stretched on them, so that ventilation openings are made in the sidewalls, gables and ridge.
8. Film is put on the soil near the sidewalls so that rainwater draining off the roof is caught and may be collected in a storage basin.

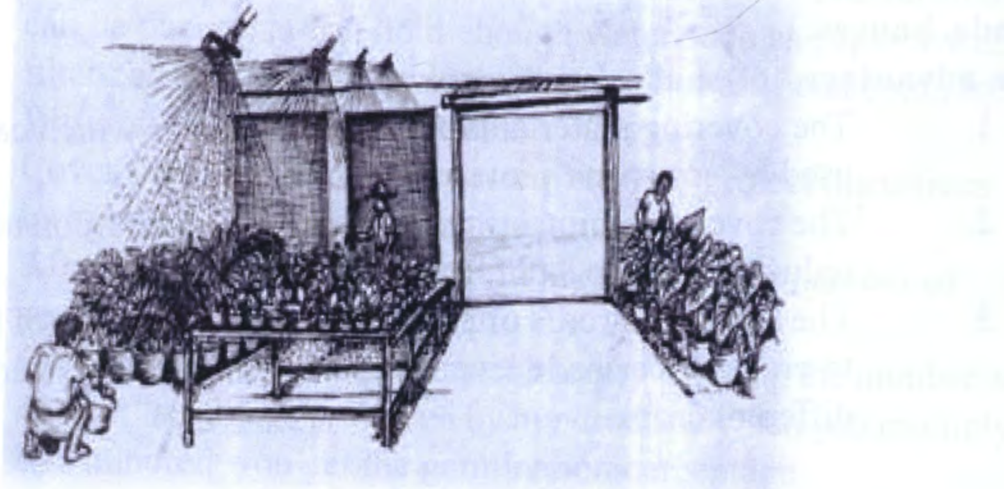
The following list of parts is for the single-span wooden greenhouse construction for vegetable production. The estimate is based on 100 square metre area, 5 metres width x 2.5 metres distance between stanchions x 8 stanchions, without small parts and film.

Part	Designation (Description)	Number
1.	round timber 80mm (3m)	9x2
2.	round timber 80mm (4m)	9
3.	square timber 50x75 (5m)	9
4.	square timber 50x75 (2.5m)	2x8
5.	square timber 50x75 (2.5m)	8
6.	square timber 50x75 (2.5m)	8
7.	square timber 50mm (2.75m)	9
8.	round timber 50mm (3m)	9
9.	square timber 38x50 (2.5m)	2x8
10.	round timber 38mm (3m)	8
11.	round timber 38mm (2.75)	8
12.	square timber 38x50 (2.5m)	2x8
13.	square timber 38x50 (5m)	2

2. **Structures with closable ventilators** are recommended for sub-tropical humid climates in tropical highlands and for dry areas to protect the crop from low night temperatures.



An expensive greenhouse with closable ventilators on the front. The roof is covered with rigid plastic and sides are screened with nylon mesh.



Seedlings are planted in containers and put on benches and irrigation is partly done with overhead mist sprayers.

Advantages and disadvantages of green houses and shade houses.

Green houses.

Green houses have the following advantages.

1. The covering material is impermeable to water and protect the crop or vegetables from rain and other environmental influences.

2. They have sloping roofs which enable the rain to flow off. The usual covering material is plastic film, since rigid materials, example glass and rigid plastics are very expensive.

The disadvantages include the following.

1. The destruction of plastic film by wind, especially strong winds such as cyclones.

2. Drop fall of water from the covering material may injure the crops.

3. Ventilation may not be efficient given the high temperature.

Shade houses.

The advantages of shade houses are as follow.

1. The covering material is permeable to water which can be used by crops and provide needed shade.
2. The cover also protects crops from wind in addition to reducing the impact of heavy rain.
3. The horizontal roofs often give the correct amount of light to crops since shade levels differ to cater for the needs of different crops.

They also have disadvantages as follow.

1. Shade cloths may not resist strong wind and heavy impact rain.
2. Shading efficiency of the covering material may not be sufficient.
3. Covering material may not be stretched and fixed sufficiently to last.

4 . PREPARATION OF SEEDS FOR SOWING

Good preparation for viable seed starts from selection of fruits to extraction of seed, washing, drying and storage for those who produce their own seeds. For commercial seeds these procedures are done by the seed company. However, it is worth mentioning here some seed preparations that farmers sometime need to do before sowing.

Germination test

Before seeds that have been stored or produced on the farm are sown in the fieldor in the nursery they should be tested for germination.

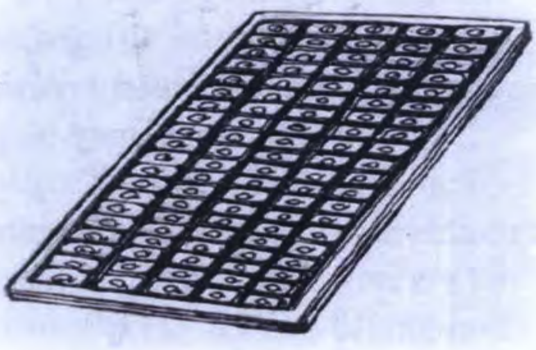
Why make a germination test?

- To determine how many of your seeds will germinate.
- The results are used to determine approximately the amount of seed to be sown to cover your production area.

What are the steps in making a simple germination method?

1. Take 100 seeds from the seed lot.
2. Arrange them in uniform spacing on a substrate. The substrate can be paper that can hold enough water such as paper towel, filter paper, blotter or cloth towel or sand or artificial compost.
3. Water to moisten the substrate.
4. Cover the seeds with a porous covering to protect them from insects and place at room temperature.
5. After every second day for eight days count the number of seedlings that have grown.
6. Germination percentage is calculated by dividing the number of normal seedlings produced by hundred and when you multiply by hundred you get the germination percentage.

Germination test using 100 seeds and germination tray. Any container of similar size may be used for this test.



Soaking or pre-germination:

Why is soaking or pre-germination necessary?

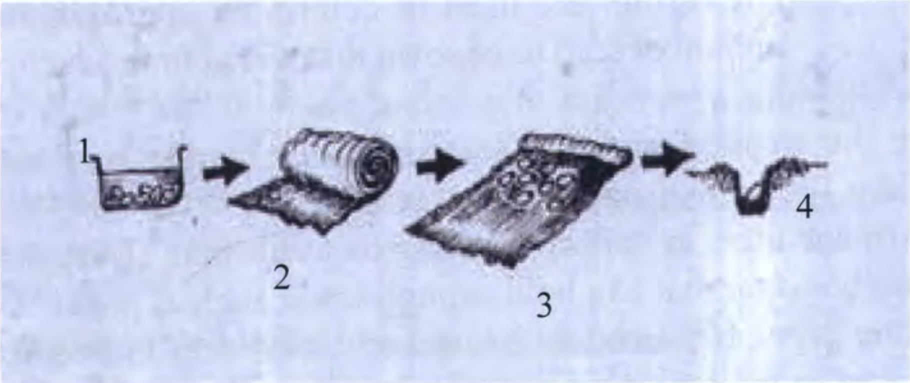
- Soaking allows for faster seedling emergence.
- Minimizes the need for constant watering in the dry season and the use of irrigation water and labour.

What seeds require soaking or pre-germination?

- This is normally required for larger seeded crops with hard seed coats such as bitter gourd.

How is soaking or pre-germination done?

- Seeds are soaked in water and wrapped in damp cloth until they start to germinate and then they are sown.



Steps in pregermination and sowing of bitter gourd seeds. 1. Seed is socked in water; 2. wrap in damp cloth for 2-3 days; 3. pregermination is complete at radicle break and 4. sowing without drying.

Seed Treatment

Why is seed treatment required?

- Seed treatment refers to any procedures that aim to disinfect the seeds or protect them from pests and diseases that may pose hazards during germination and later stages of plant growth.

What are the types of seed treatments?

- Treatments may be **physical** or **chemical**.

What are some physical treatment methods.

- Soaking seeds in warm water

Example: Cabbage seeds are soaked in warm water (45°C) for 20 minutes to control black rot.

Steps in warm water treatment.

1

Boiling water to adjust soaking temperature to desired level.

2

Water temperature is kept to desired level by constant addition of boiling water whenever the temperature falls below the desired temperature.

3

Air drying.

4

Sow immediately

- Applying dry heat for a period of time to disinfect seeds.

Example: Green pepper seeds heated in oven at (76°C) for three days
following a waiting period of three months after harvest always eliminated all seed-borne viruses.

What are some problems of these heat treatments?

- Reduce viability of stored seeds.
- Reduce germination ability of seeds so alternative methods must be explored before using heat sowing treatment. **If heat treatment is to be used it is advised to apply just before sowing.**

Chemical treatment usually consists of a, fungicide, insecticide or a mixture of both mixed in with the seeds. Diluted concentration of sulphuric acid is used against bacteria, fungi and viruses. The two basic methods of application are the (a) dry or dust method and (b) the "slurry" method where seeds are immersed in the mixture of the chemical.

What are some commonly used chemicals used for treatment?

- The most common fungicides used for seed treatments are Thiram and Captan. Both are broad spectrum in action and have low mammalian toxicity.
- The systemic fungicide Ridomil is applied to provide protection against fungal diseases up to maturity.
- Among the insecticides, Gardona and Malathion provide protection against weevils.
- Common disinfestants are detergents such as sodium or calcium form of hypochloride and trisodium phosphate. Commercial bleaching preparations, such as Clorox 10% solution is also being used.

Scarification

Why is scarification required?

The main aim of scarification is to soften or to make a wound on the seed coat so that water can be easily absorbed by seeds, thus hastening germination.
Scarification procedures are applied to hard seeded crops such as okra and some legumes.

How is scarification applied?

Seed scarification may be done by **chemical means** or by **physical means**. For small growers of the South Pacific region physical means of scarification is recommended.

What are some commonly used chemicals?

- Chemicals such as acetone, alcohol, hydrogen peroxide, sulfuric acid, hydrochloric acid, and sodium hydroxide may be used to scarify seeds but do not use too much or it will cause injury.

Chemical acid treatment

1

Treat with concentrated sulphuric acid for a few minutes.

2

Dilute with water.

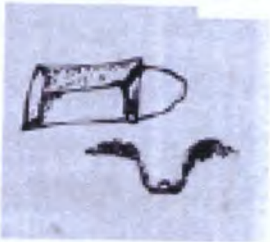
3

Rinse thoroughly

4

Air-drying.

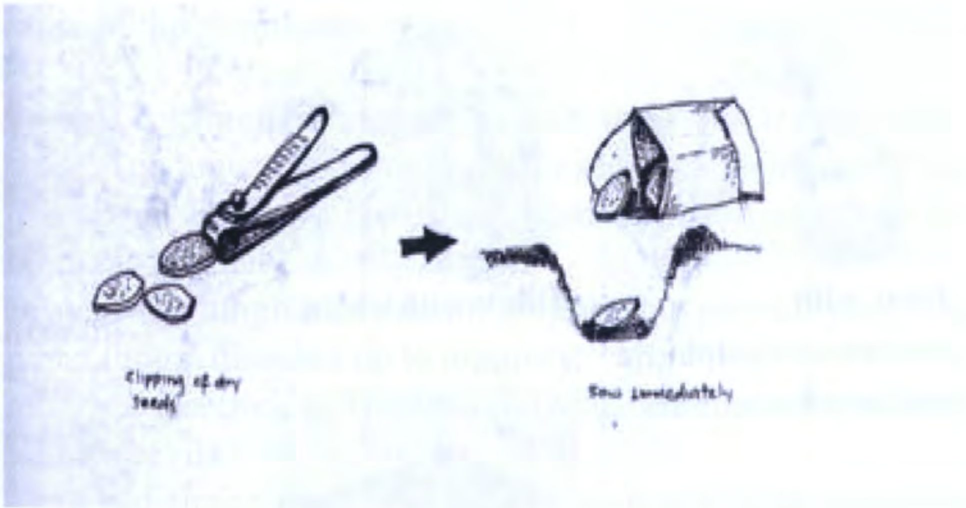
5



Sow immediately (do not store).

What are some physical scarification methods?

- Chipping hard seed coat by rubbing seed with sand paper or cutting with a file.
- For large scale operations special scarifiers are used. Seeds may be tumbled in drums lined with sand paper combined with coarse sand or gravel. The gravel should be of a different size to facilitate separation.
- Large seeds that are flat in shape such as water melon seeds are clipped at the side with a nail cutter taking care that the cotyledon and embryo are not damaged.
- Seeds may also be scarified by immersing into four to five times its volume of hot water (77 – 100°C) and heat source is removed immediately allowing seeds to soak for 12 to 24 hours as the hot water is cooling.
- Keeping seed in a moist warm non-sterile medium (sandy soil) for several months can soften seed coat through micro-organism activity.
- Seed exposure to high temperatures also modifies seed coat.



Physical scarification. 1. Clipping of seed coat. 2. Sow immediately

Seed Hardening

Why is hardening useful?

- Seed hardening is a treatment applied to the germinating seed, and its effect is seen on the developing plant.

How is seed hardening carried out.

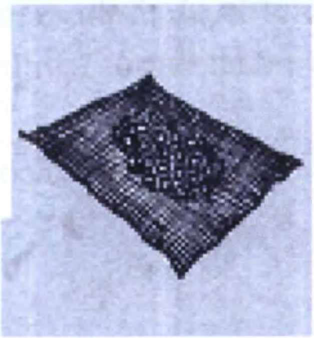
The process consists of air-drying seeds that have started to germinate but have not produced a radicle. The hardened seeds are sown immediately

Steps in hardening of tomato seeds

1

Soak until imbibition is complete but just before radicle break.

2



Air dry.

3

Sow immeadiately.

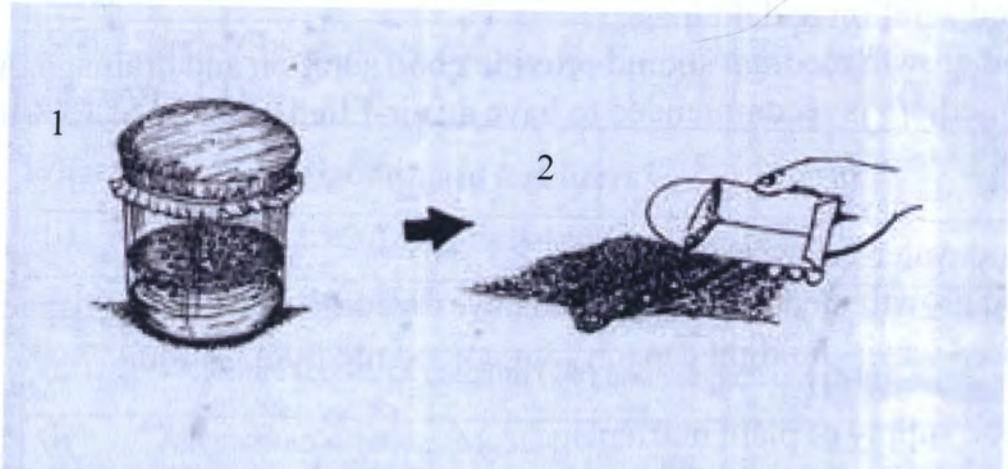
Seed Conditioning

Why is seed conditioning important?

The procedure improves the germination of seeds that have been over dried and stored under low moisture content (such as canned seed stored at low temperatures) by exposing the seeds to high humidity for several days beforesowing.

How can seeds be conditioned?

A practical way of doing this is to put seeds on a wire screen tray suspended in a sealed jar with water for several days with out wetting the seeds.



Preconditioning of pepper seeds. 1. Suspend seeds on wire tray over water in airtight container for two days. 2. Sow immediately

How is seed hardening done?

The process consists of air-drying seeds that have started to germinate but have not produced a radicle. The hardened seeds are sown immediately

5. GROWTH MEDIA MADE FROM LOCALLY AVAILABLE MATERIALS

What is a potting mixture?

The terms potting soil, mixture or compost are all used to refer to the growth medium used to sow seeds in or to raise plants in, in containers or plastic bags. Soil is the universal medium for germinating seeds and growing seedlings. However, it is not necessarily the best medium.

Where can we buy potting mixtures?

- There are special mixtures of perlite, vermiculite and peat that are commercially available in ready-to-use mixes for specific purpose and are used for substitute for soil.
- However, these are normally expensive, and they are not readily available to most growers in all countries of the region who are mostly small growers with limited resources
- This is why farmers should make their growth media composing of cheap locally available materials.

What are the qualities of a good medium?

a) Good aeration and drainage

A good growth medium should provide good aeration and drainage. A good medium is recommended to have an air-filled porosity of 13% and above.

b) Good water-holding capacity

A good growth medium should also have a good water-holding capacity. Required water- holding capacity for a good medium is around 40%.

c) Good supply of plant nutrients

Another quality of a good growth medium is that it should have the capacity to supply nutrients to plants. Nutrient rich materials such as compost, manure or fertile topsoil should be added to a medium to supply plant nutrients. Chemical fertilisers can also be added for nutrient supply. There are a number of chemical fertilisers available in stores.

What are the air-filled porosity and water-holding capacity of some local materials and their mixtures?

Medium components and mixs	Air-filled porosity	Water holding capacity
Top soil	6.6	43.7
Sand	10.5	26
Wood shavings	46,1	15.3
Sand + Soil	6.6	33.3
Sand + Wood shavings	32.9	17.7
Soil + Wood shavings	24.3	27.9
Soil + Wood shavings + Sand	19.2	27.2
Soil + Sand + Chicken manure (3:1:1)	26	38

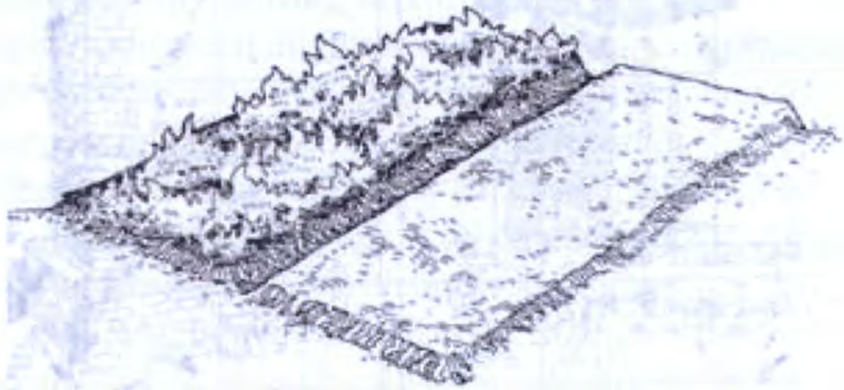
What are some commonly used fertilizers?

(i)	N.P.K. (12:5:20) commonly known as banana fertiliser
(ii)	Nutricote (8-9 month slow release fertiliser)
(iii)	Dolomite (contains calcium (Ca) and magnesium (Mg)
(iv)	Magnesium sulphate (MgSO4)
(v)	Zinc sulphate (ZnSO4)
(vi)	Iron sulphate (FeSO4)
(vii)	Ferro (contains potassium (K) plus the micro elements copper (Cu), manganese (Mn), iron (Fe), zinc (Zn(, boron (B) and molybdenum (Mo))
(viii)	Yates's "Thrive"a soluble complete fertiliser to provide balanced nutrients required by crops.

Methods of sterilizing growth media

1. Raw heat method simply involves burning of straw on top of the seedbed. Gives media freedom from soil-borne plant pathogen

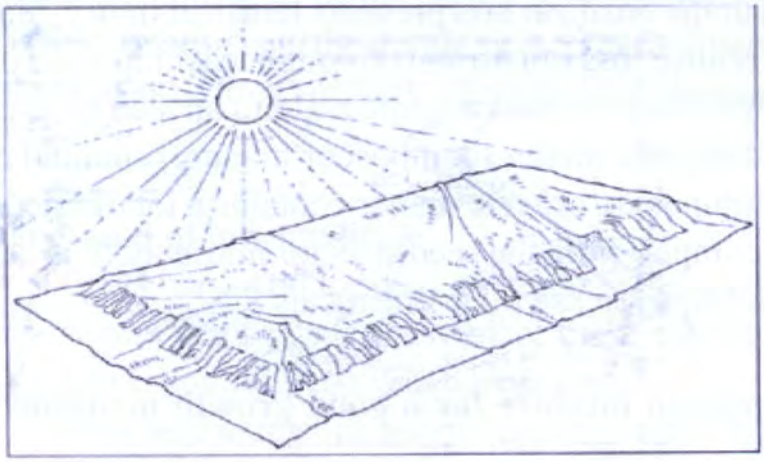
A good growth medium should be free from soil-borne plant pathogens and therefore, it is very important to sterilise the medium, especially when the components have been used defore. Sterilisation of growth medium may be done in many ways.



2. **The hot plate sterilisation method** is basically heating the medium in a metal container over an open fire. Electric sterilisers are also available. The medium is heated by direct heat and steam.

Sterilization by hot plate

3. **Solarisation** is basically sterilising the medium by raising its temperature by direct sunlight. The medium is covered with a clear plastic and exposed to full sunlight.



Why is pH of the medium important?

Plants take up nutrients from (soil and or fertiliser) only through the absorption of water. This means nutrients have to be dissolved in water before they can be taken up by plants. The pH of the medium determines how much of a nutrient or element will dissolve and will be available to the plant. If the pH is too high or too low some nutrients will not be available to plants resulting in deficiency symptoms and retarded growth. A good pH range is from 5.5 to about 7. You may test pH of your medium at a local research station or high school.

What are the pHs of some local medium components and mixes?

	PH_{H2O}	pH_{KCL}
River sand	8.2	7.4
Coconut	7.4	6.6
Soil	5.8	5.5
Mix	7	6.5
Soil + sand + compost	6.4	-
Soil + sand + wood shaving	6.6	-

Fertilizer applied to the seedbed must be mixed with the soil before, not after sowing. Seedlings must be able to use the fertilizer immediately after it has developed the root system which absorbs the nutrients. Also, mixing of the fertilizer with the soil before sowing provides an even distribution of the fertilizer and prevents fertilizer injury. Slow release fertilizer to reduce loss of nutrients through leaching should be used. In the tropics well decomposed organic matter can also be used. Only fully decomposed organic matter (compost or manure) should be used because decomposing organic matter contains a lot of micro-organisms which may compete with the seedlings for nutrients. The decomposition process also helps release toxic chemicals

What is a proven mixture for a good growth medium?

* Three parts fertile top soil + one part river sand + one part dry chicken manure or compost or 20 grams of a complete fertilizer (NPK).

Mixing the medium and filling the seed trays.

6. TECHNIQUES OF SEED EXTRACTION AND PRESERVATION

Seed production at the farm level by the farmer is still the most common source of seeds for the farmers in the developing countries (particularly small vegetable farmers). However, very often the seed produced is of low quality.

Why is farmers' seed of low quality?

- Fruits harvested for seed are those at the end of the season when plants are weak or those missed from harvesting for fresh vegetables.
- Poor seed extraction and processing methods.
- Disease and pest infection in storage.
- Inadequate storage condition.

How can farmers produce quality seeds?

Hence the training of farmers in seed production is of high importance to ensure seed available are of high quality. It is in the interest of this toolkit to train you in how to properly extract seeds from fruits and store them to ensure good seed quality is maintained for as long as possible.

Harvesting and processing

Seed crops of vegetables can be grouped according to the state of the seed at harvest. This is important because knowing the state of seed at harvest will enable you to extract and process the seed correctly.

1. **Dry Seed:** The seeds are not harvested when the fruits ripen but are left to dry on plants in the field. Examples of vegetables in this group are beans, sweet corn, *Brassicas*, okra, carrot, onion and lettuce.

2. **Seeds of Fleshy Fruits**:
   (i) Seeds with mucilaginous coating. Examples are tomato and cucumber.
   (ii) Seeds without the mucilaginous coating. Examples are pepper, eggplant, melon and squash.

Seed of fleshy fruit

Drying of the Pods/Fruits

- In wet areas physiologically mature fruits are harvested and air-dried under sun or shade.
- Wet fruits/pods may be hung above wood oven to hasten drying and may prevent insect pest infection.
- When drying with artificial heat, the temperature must not be above 30°C when seed still has high moisture content greater than 20% to avoid heat injury.

Drying pods/fruits on plants.

- Some fruits are left to dry out in the field after they have reached physiological maturity.
- At physiological maturity, the development of the embryo and accumulation of storage material are almost complete, the moisture content of seed is about 50% wet basis.
- Seed then start to loose moisture due to the heat from the sun while it is still on the plant.
- Soon the seed is harvested and further dried before storage. Beans and other leguminous vegetable s are usually allowed to dry on vines and harvested soon before pods start to shatter. Other vegetable seeds harvested dry are *Brassica* crops, okra, onoin, kangkong, sweet corn, lettuce and carrot.

- Drying heat can later be increased to 35°C - 40°C when seed moisture reduces.

Threshing and Processing of Dry Pods/Fruits

In the developing countries seed threshing is usually done manually with a stick or rubbing and splitting by hands. This is because the volumes of pods to be threshed are normally small. Pods are easier to thresh if they have been sun dried. This will make them brittle. Trash is removed by winnowing. Other rubbish like poor seeds and pieces of inert matter are picked by hand.

Clean seed is further sun-dried to a moisture content of 8%. The drying place must be well ventilated and seeds turned from time to time.

A seed is dry when it becomes hard and brittle and when broken with a hard object will shatter with a characteristic popping sound. Wet seed is still elastic therefore will not break.

Extracting and Processing Seeds of Fleshy Fruits

Seeds with the Mucilaginous Layer.

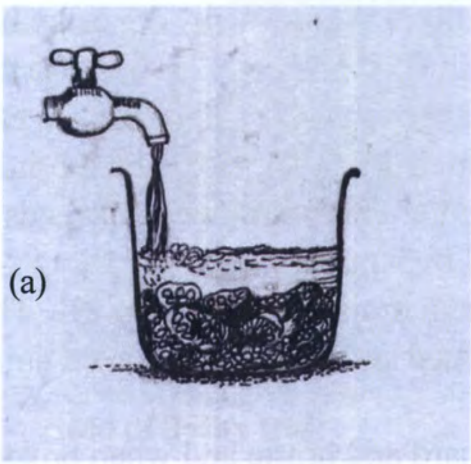
Seeds with the mucilaginous layer are commonly processed by natural fermentation or sometimes where practical by acid treatment.

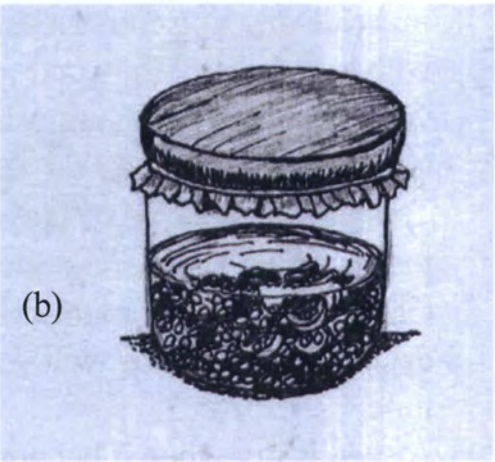
It is important that for a small vegetable grower natural fermentation is recommended.

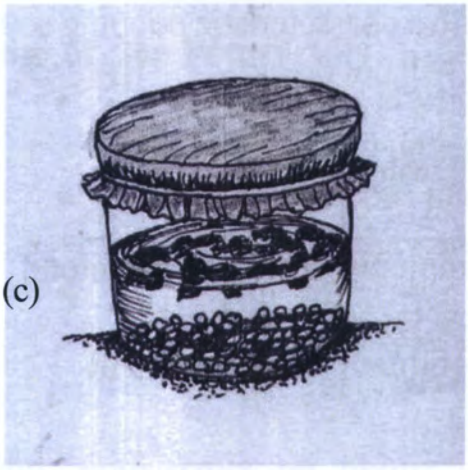
Fermentation:

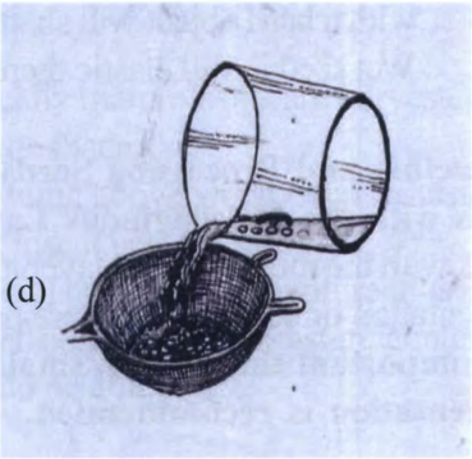
- Seeds of fully ripe tomato fruits can be extracted right after harvest or after a post-harvest incubation period of ten days in storage for cucumber.
- The seeds are extracted into a non corrosive container by hand or with an appropriate simple tool such as a spoon after fruit is crushed or cut open.
- The seed and pulp in the form of slurry is left to ferment in the shade away from direct sunlight. The pulp should be stirred regularly to help release the seeds and to prevent mould growth from discolouring the seeds.
- Fermentation usually completes after 2 days at pulp temperature of 22 – 27°C and 2 to 4 days at 15 – 22°C. At this stage the bubbling activity of carbon dioxide being released from fermentation is reduced and the slurry cools

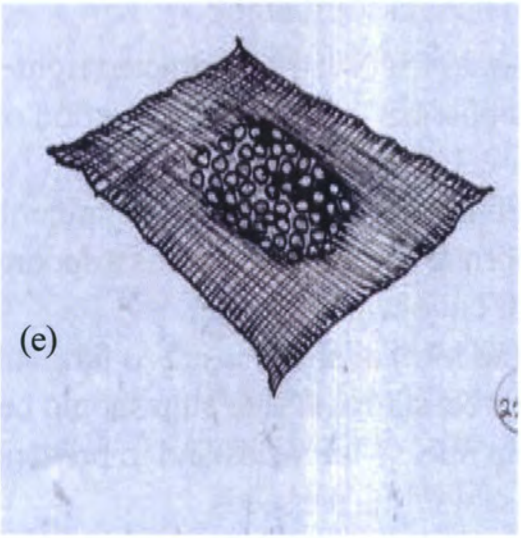
down and decreases to the initial volume, and the supernatant of the slurry clears up. A more practical indication is the sinking of the seeds to the bottom of the container.







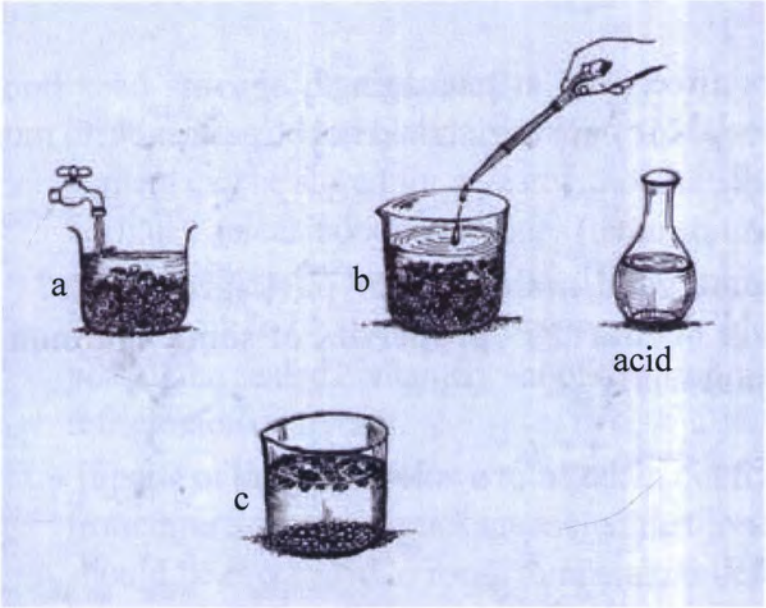




Fermentation of seeds. (a)slurry is added some water (b) slurry covered and fermenting indoors (c) fermentation over, seeds sink to the bottom and pulp and bad seed float to the top (d) seed after washing in water is sieved (e) washed seed;

Acid Treatment:

- Seed and pulp is extracted into a non-reactive container (glass)
- The hydrochloric acid is added at a rate of 6 litres per 100 kg of pulp or 0.06 millilitres per gram of pulp.
- Stir to thoroughly mix and allow the acid to work for 30 - 40 minutes, or until the pulp and the mucilaginous coating surrounding the seeds have broken down enough to be washed easily.
- The seed is then washed very well excess pulp is floated off .



Acid Treatment. (a) Slurry after extraction is added some water (b) Hydro-chloric acid added 0.06 ml per gram of pulp (c) forty minutes later seed sink to the bottom pulp and bad seed float ready for washing

Seed without the Mucilaginous Layer

The seeds of these fruits are processed by just washing in a lot of water. Examples are pepper, eggplant melon and squash etc.

Farm Level Packaging and Storage

Well cleaned and dried seeds have to be packaged and stored properly before planting. Good storing conditions help maintain high seed viability.

What factors affect seed viability during storage?

- Seed moisture content
- Seed temperature.
- When both moisture and temperature are high seed viability deteriorates rapidly.

What factors affect seed at packaging?

1. **Material for packing**: should not be permeable to moisture, gas and oil.

What are some good materials for packaging seeds?

A comparison of barrier properties of some common flexible packaging materials[a]

Material	Property (resistance to) Water vapor	Gas transmission	Water	Oil grease
Kraft paper	0	0	2	0
Sulphine paper	0	0	2	0
Glassine paper	0	3	3	4
Waxed glassine paper	4	5	5	6
Cellulose	0	6	5	10
Cellulose acetate	1	2	6	6
Polyvinylchloride (PVC)	2	5	10	8
Mylar	4	6	10	8
Polyethylene (PE)	7	3	10	5
Polyvinyldichloride (PVDC)	9	8	10	8
PE coated paper	7	3	6	5
PVDC coated paper	8	8	6	8
PE coated cellulose	8	8	6	6
Aluminum foil (9 micron)	10	10	10	10

[a]Source: Klaasen 1983. Qualities are graded from 0-10, where 10 is the highest grading and 0 signifies that the quality is nonexistent.

2. **Seed temperatures:**
Seeds should be cooled down before they are package.

3. **Packing procedures:**
Seed may be kept inside a thick polythene packet fastened or sealed tightly before being packed in container. PE may be sealed by heat or with an electric heat sealer. Bottle stoppers should be sealed with molten wax or candle after tightly secured. Use blue silica gel as an indicator in large storage bottles.

Storage

What are good seed storage procedures?

- Dry seeds sealed very tightly at around 8% moisture content can be stored for a year without much problem in normal tropical indoor conditions (temp around 30°C) if the initial quality of the seed lot is good.
- If seeds are to be stored for longer periods of time (10 years), the sealed containers should be stored in a refrigerator or freezer.
- If parts of the seed lot have to be taken out for planting from time to time, the package including the seeds inside should be rewarmed to room temperature before the seal is opened. This will prevent atmospheric water vapour to condense on the remaining seeds in the package.

Seed Treatment

It is best not to treat the seed with agro-chemicals before and during storage if the seed is clean and healthy, and the seed package has to be kept in kitchen or in a household refrigerator. Recommended treatment can be done just before planting to prevent unwanted food contamination.

7. SEEDING RATE CALCULATION AND SOWING FREQUENCY

Why calculate seeding rates?

Seeding rate refers to the amount of seeds sown in a certain area.

- Seeds are becoming more and more expensive especially seeds of high quality cultivars.
- High seeding rates in the nursery may lead to over production of seedlings, weak seedlings or seedling deaths due to over-crowding.
- Conversely low seeding rates in the nursery may result in the failure to produce sufficient seedlings to completely plant a prepared field.

To avoid wastage of resources it is most valuable for you to be able to calculate amounts of seeds to sow in the nursery. There are several ways of calculating seeding rates. For our purpose this simple method would be sufficient.

Calculating Seedling Rates

Example: Let us say that you want to plant Chinese cabbage in an area which is $50m^2$. The recommended spacing you are to use is 30cm between rows and 20cm between plants within rows.

Other very important information that should be known to the farmer is:

(i) There are approximeatly 300 seeds of Chinese cabbage in one gram of seeds.

(ii) Germination percentage of the seed lot is given on the seed package as 80%

(iii) There are 100 centimeters in one meter.

How much seed should the farmer sow in the nursery to cover an area of $50m^2$?

Step one

Change centimeters in meters and calculate area of one plant in meters squared. 0.3 m x 0.2m = **$0.06m^2$**

Step two

Calculate the number of cabbage plants that would fit in $50m^2$ at the given spacing.

$50m^2$ / 0.06 m^2 per plant = **833 cabbage plants in $50m^2$ of land**

Step three

Calculate grams of seeds required for 50 m^2 of land using the information that one-gram of seeds contains 300 Chinese cabbage seeds.

833 cabbage plants in $50m^2$ / 300seeds per gram = **2.77 grams per $50m^2$ of land**

Step four

Calculate the actual weight of seeds required for $50m^2$ given the information that the germination percentage is 80 or 80%.

$$\frac{2.77\ g/50m^2}{0.8} = \underline{\textbf{3.46 g of seeds per } \mathbf{50m^2}}$$

In order to raise enough seedlings to completely cover $50m^2$ of land utilizing the recommended spacing you are required to sow approximately 3.5 grams of Chinese cabbage seeds in the nursery.

Why is staggered planting important?

Staggered planting is the practice of planting sections of a seedbed or a larger area in succession with the same crop. Staggered planting ensures a continuous harvest of that crop for the market or supply of the crop for the family.

What important information should you know before successfully planning a growing calendar for a continuous harvest?

- **Growth duration** of the crop, that is how long it grows from planting to maturity.
- **Time normally taken to raise seedlings in the nursery.**
- **Estimate of the harvest window** or how long a crop is harvested before it dies.

All these infromation become more accurate with experience of growing a particular crop.

Example 1: Direct Seeded Crop

Beans

Beans can be grown both in the wet and dry season so they can be produce year round.

Growth to first harvest normally takes about 8 weeks

Harvest duration normally 4 weeks

Growth Duration (sowing to maturity) normally 12 weeks

The first crop is sown in the first week of January and matures in the last week of February. Harvest takes up the whole 4 weeks of March and then the crop dies.

To ensure a continuous harvest and supply the second crop should be sown four weeks after the first crop is sown, that would be the first week of February. It would grow for eight weeks (February – March) and mature in the first week of April, harvest would be during the four weeks of April.

Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Grow	Grow	Har									
	Grow	Grow	Har								
		Grow	Grow	Har							
			Grow	Grow	Har						
				Grow	Grow	Har					
					Grow	Grow	Har				
						Grow	Grow	Har			
							Grow	Grow	HAr		
								Grow	Grow	Har	
									Grow	Grow	Har
										Grow	Grow
											Grow

A Planting Calendar for a continuous harvest of beans. New plantings of beans should be done every four weeks.

Example 2 : Nursery raised crop.

Chinese Cabbage

Chinese cabbage is normally grown for about 3 weeks in the nursery and another three weeks in the field and its harvest duration is about 2 weeks.

To ensure a continuous harvest new sowing should be done in the nursery 2 two weeks.

Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Grow	Grow	Har									
	Grow	Grow	Har								
		Grow	Grow	Har							
			Grow	Grow	Har						
				Grow	Grow	Har					
					Grow	Grow	Har				
						Grow	Grow	Har			
							Grow	Grow	HAr		
								Grow	Grow	Har	
									Grow	Grow	Har
										Grow	Grow
											Grow

Growing Calendar for a continuous harvest of Chinese cabbage. Nursery sowing should be done every second week to ensure a continuous harvest and supply.

8. METHODS OF SOWING SEEDS IN A VEGETABLE NURSERY: Theory and Practice.

Methods of sowing seeds in the nursery recommended in this toolkit are:

- Drilling with uniform spacing.
- Drilling in line at high density

. The commonly used broadcast method is not recommended in this toolkit because of the high loss of seedlings usually associated with it and hence it is not regarded as a cost effective method.

Categories of vegetables depending on planting/sowing practice.

- **Crops Usually Transplanted**

  Cabbage Chinese cabbage Broccoli Cauliflower Tomato Eggplant Pepper

- **Crops Usually Direct-Seeded**

  Watermelon Cantalope Squash Cucumber Peas Beans

- **Crops That Should be Direct-Seeded**

  Radish Carrot Turnip

Source: Asian Vegetable Research and Development centre, Tainan, Taiwan, 1990.

Sowing Methods

1. Drill Sowing with Uniform Spacing Method

- The drill sowing with uniform spacing method is the practice where seeds are sown in rows at a certain distance from each other.
- When a weed problem is anticipated and mechanical control will be used and
- When seeds are expensive

Advantages

1. There is no necessity for pricking or thinning therefore there is a less demand for labour, time and nursery resources.

2. The probability that seedlings might be damaged is low since there is only one transplanting.

Disadvantages

1. Planting seeds at a uniform spacing in the nursery bed or in containers is gruelling and time consuming especially when sowing many containers

Steps in sowing with uniform spacing

1. Drill sowing with uniform spacing technique.

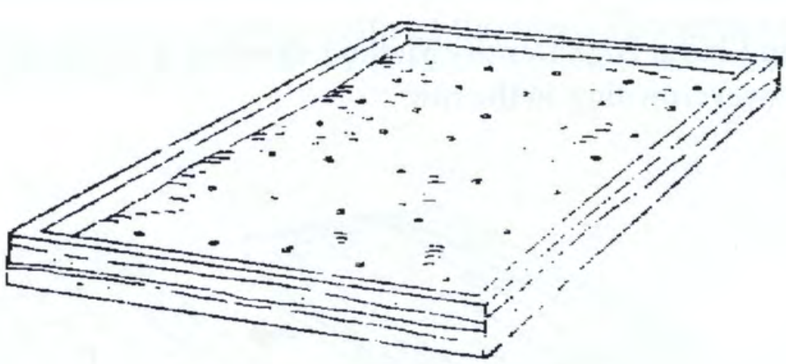
Step 1 Make planting holes about 1 cm deep in the prepared seedbed or container medium. The holes should be 5 cm apart between rows and 5 cm between plants within the rows.

Step 2 Sow one seed per hole and sprinkle some more medium to cover the seeds.

Step 3 Water in the seeds from above the medium using a can with a fine rose.

Step 4 Label the seeds with their full name and sowing date and put the sowed containers in the greenhouse.

Drill Sowing with uniform spacing method.



2. Sowing using the high density in line method

The sowing at high density in line method is when seeds are sown in a line at no particular spacing . The seeds are close together and touch each other. The seedlings are later pricked and grown at uniform spacing in other containers or seedbeds.

Advantages

1. Reminiscent of the broadcast method the sowing process is fast and does not require much labour and time to sow seeds.

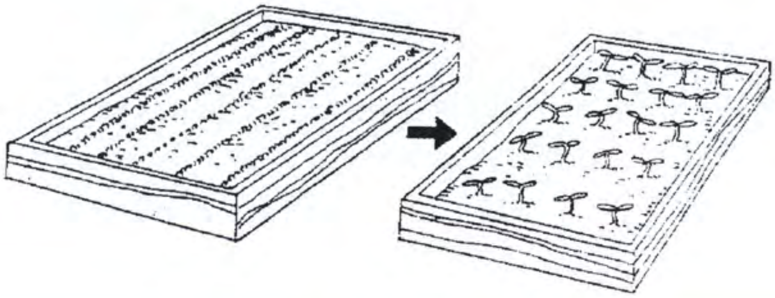
Disadvantages

2. Like the broadcast method it requires prickling which increases the need for labour and time and also increases chances of seedling damages due to additional handling.

Steps in sowing in lines at high density

Step 1	Make furrows about 1 cm deep across the seedbed or container medium. The lines should be about 5 cm apart.
Step 2	Lightly sow seeds in the furrows
Step 3	Sprinkle some more medium along the furrows to cover the seeds.
Step 4	Water in the seeds from above the medium using a can with a fine rose.
Step 5	Label the seeds with their full name and sowing date and put the sowed containers in the greenhouse.

Sowing in Line at High Density Method showing the problem of seedling overcrowding in the row



4. General guides to depth of sowing seeds.
All seeds whether planted directly of sown in a nursery have to be buried in the ground. How deep you bury the seeds is very important. If seeds are buried too deep they may not be able to emerge or emergence would be very slow. It is also important to sow all seeds at the same depth to ensure uniform germination. Uneven germination will result in an uneven crop stand which will in turn affect later crop production activities such as harvesting.

Depth of seed placement is influenced by several factors, including seed size, type of seedling emergence, soil type and depth of soil moisture which is associated with soil type.

Large seeds have more food reserves and can emerge from lower soil depths while depending on stored energy. Small seeded crops have limited food reserves and are planted at shallow depths.

Species with epigeal germination need to emerge above soil to commence seedling establishment. If seeds are planted too deep, emergence may be delayed, and seed may rot in the process.

Seeds sown in heavy clay soils should planted at shallow depths since heavy soils are cold, poorly drained and aerated and prone to crusting. In contrast, light sandy soils drain freely and are prone to drying especially in the surface layer. They also provide less impedance to emergence. Seeds may be sown deeply in such soils.

If no information is known on how deep to sow a seed it is best to follow this practical guide. Seeds should be planted at a depth equal to about 2 to 3 times the diameter or width of the seed. This general rule of thumb is true for most seed.

9. NURSERY MANAGEMENT PRACTICES

Seedling care:

Now that we have already talked about nursery making and sowing, let us now talk about how to look after the seedlings in the nursery after they have emerged. We will look at nursery management under these headings of protection from wind, thinning, watering, fertilization and seedling hardening. Disease and pest management is covered in the next section of the toolkit.

Protection from wind

When seeds germinate they will be exposed to a number of deleterious influences which may reduce growth or even cause death. The worst is the effect of wind, which causes stress in seedlings. Watering will not necessarily alleviate the situation as the seedlings may not take up water quickly enough to compensate for water loss. The most common way of protecting a nursery from wind is providing a cover materials around the nursery shelter. These materials may be clear plastic or coconut fronds. Some farmers plant hedges around the nursery as wind breakers.

Placing coconut fronds or a using a plastic material to cover the sides of the nursery shelter protect the nursery from strong winds.

Thinning

Close spacing should be avoided, as this will cause plants to compete with each other for light, nutrients and moisture. Plants should be spaced so that the leaves of adjacent plants are not touching.

To prevent overcrowding, you should take these thinning guides.

1. Thin seedlings in trays or seedbeds at about the 3 to 4 leaf stage.

2. Seedbed plants should be thinned to about 10 cm apart in the row.

Thinning Process. Seedling are spaced out in the nursery bed about 10 cm apart.

Watering

Seedlings must never be allowed to dry out, but over-watering should be avoided as this encourages "damping off" diseases. Watering should be done carefully until seedlings emerged, especially when the seeds are small.

Application of water

- should also be done in the morning and if it needs to be repeated should be done in the early afternoon.
- Do not wet seedling leaves in the evening, as this encourages disease like 'damping off'.
- About ten days before transplanting watering should be decreased, this practice is important in seedling 'hardening' which we will discuss later.
- Clean water must be used for watering, therefore tap water or water from a deep well must be used. Surface water may carry weed seeds as well as pathogenic micro-organisms.

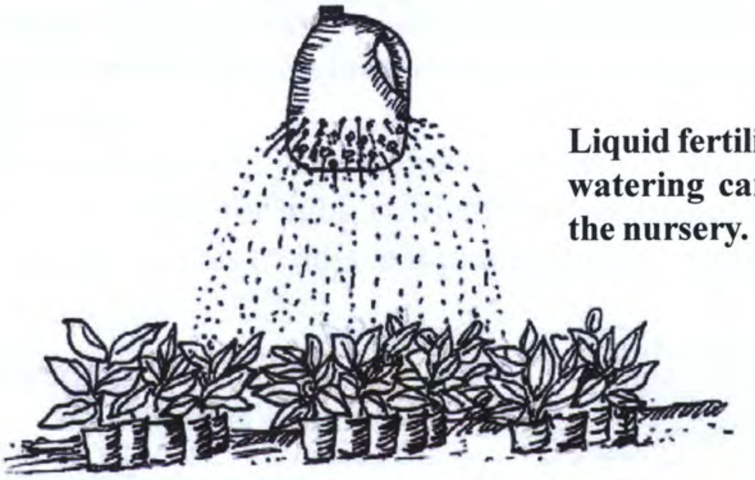
Watering using a plastic bottle with holes made at the bottom.

Watering using a watering can.

Fertilization

If fertilizer needs to added to the seedlings while in the nursery it can be applied in two ways.

1. Apply as liqiud fertilizer
   - Liquid fertilisers can be applied as drench (starter solution or as foliar sprays). This can be made from dissolving 10 grams urea into 5 litres of clean water, or 30 grams of a compound fertilizer (NPK) in 15 litres of clean water. There are other foliar applied fertilizers available in agriculture stores (see part on fertilization in section on Growth media).
   - Some farmers put a sack of chicken manure into a 44 gallon drum of water and use the water to fertilize seedlings.
2. Granular fertilizer is side dress or applied about five centimeters below the medium between the lines of seedlings.



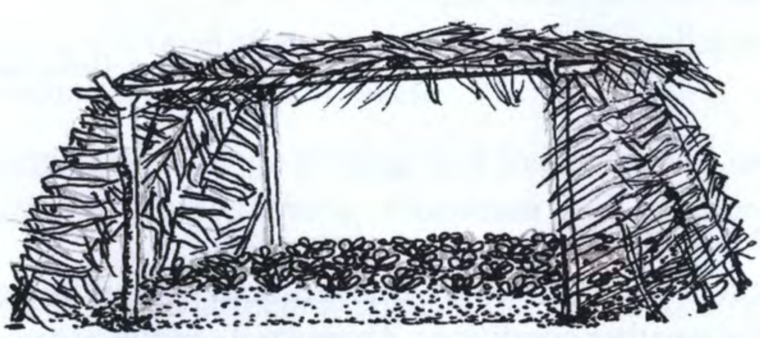
Liquid fertilizers is applied by watering can to the seedlings in the nursery.

Hardening Process
Hardening involves the reducing of seedling growth which result in accumulation of carbohydrates, which makes the seedling better withstand adverse environmental conditions after transplanting.

Hardening involves:

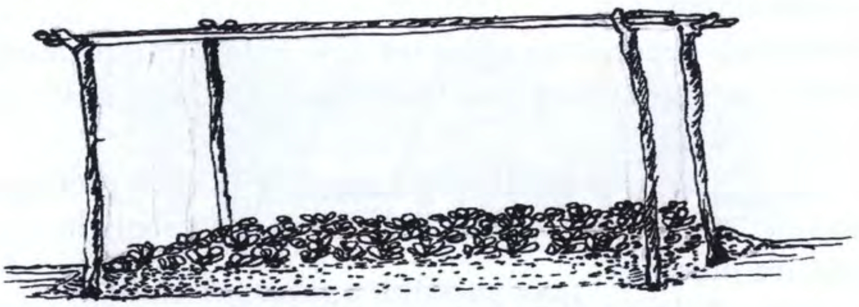
* Gradually reducing the water supply over a ten day period prior to transplanting.
* Increasing temperature about ten days before transplanting.
* Seed boxes are shifted from the nursery to an open field exposed to direct sunlight
* For seedbed raised seedlings the temporary shelter roofing material and side covering material is removed to allow sunlight into the nursery.
* In non-cellular seedling trays it is good to prune roots one week before trans planting by passing a knife around each seedling. This stimulates root branching and assures a good shoot-root ratio and creates a dense root system.

BEFORE

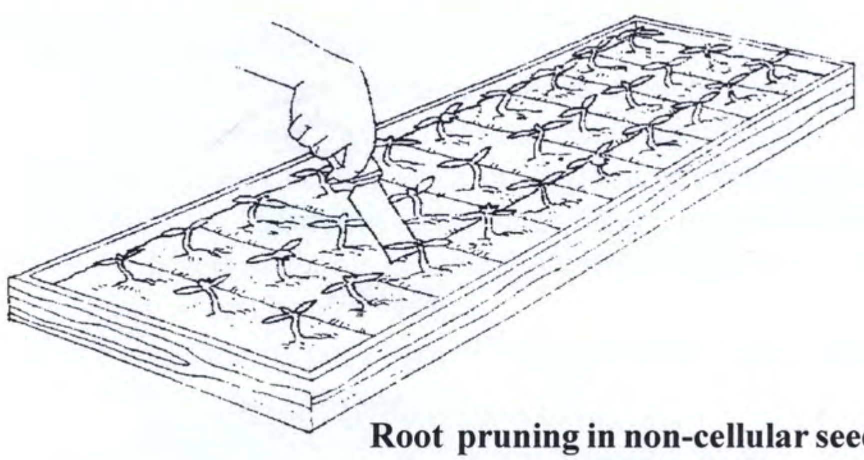


A s
eedbed nursery with its shelter cover material before the hardening process

AFTER



The hardening process involves removing the shade material from the shelter to increase sunlight and air temperature availableto the seedlings. Watering is also reduced about ten days before transplanting



Root pruning in non-cellular seedling trays

Oversized seedlings

This problem is often caused by delayed field preparation and unfavourable weather conditions. Oversized seedlings are not only difficult to handle during transplanting but have smaller chances of surviving field conditions. Oversized seedlings can be avoided by prolonging the hardening process.

10. MOST COMMON NURSERY PESTS AND DISEASES IN

This section highlights only selected most common problems in nurseries, as detailed treatment of all problems is beyond the scope of this tool kit.

First, here are some general good practices for managing nursery pests and diseases:

i. Aim to provide good growing conditions for your plants (good soil, nutrients, light, drainage, water).

ii. Use clean, healthy planting material.

iii. Practice good sanitation (e.g. eliminate infested plants promptly; thoroughly sterilise potting soil before re-using; clean and disinfest tools, benches and similar surfaces, and pots that are used repeatedly).

iv. Check nursery regularly in order to spot problems early and deal with them.

v. Learn to identify natural enemies of pests (e.g. spiders, wasps, ladybird beetles, ground beetles, certain ants) and avoid destroying them.

a) Damping off

Symptoms: Seedlings fail to emerge due to seed rot or seedlings fall over at soil level after emergence. Stems of collapsed seedlings appear very thin at soil level.

Causal agents: A wide range of fungi that live in the soil including *Pythium, Phytophthora, Fusarium* and *Rhizoctonia.*

Hosts: A disease that affects a wide range of plants that are raised from seeds (tomato, capsicums, cabbage, eggplants, okra, etc.).

Conditions favouring disease: Very wet seedbeds in warm conditions, seedbeds with high organic matter, and growing seedlings in highly shaded areas.

Control:

- If sowing seeds in the ground, do not sow where a host crop has just been removed.
- Remove organic matter that is not decomposed from the seedbed.

b) Wilts

Symptoms: Infected plants droop even when soil moisture is adequate. Plants eventually die.

Causal agents: A disease caused by several pathogens such as fungi (e.g. *Fusarium*) and bacteria (e.g. *Ralstonia*).

Hosts: A wide range of plants including tomato, capsicum, eggplant, and okra.

Spread: Through contaminated soil, tools, irrigation water, running surface water, infected transplants and seed.

Control:

- Use resistant varieties, if possible.
- Use clean soil for seedbeds.
- Plant only clean seeds.
- Use clean garden tools.
- Do not establish seedbed where wilt has been a problem.
- Do not irrigate seedlings with ditch or pond water as such surface water might be contaminated with the disease-causing organisms.
- Do not flood nursery area (to avoid spreading the pathogen).
- Practice rotation with non-host plants.

c) Aphids

Aphids are small, soft-bodied sucking insects (greenish, black, yellowish, grey or brown in colour). Most do not have wings. Aphids can be easily observed on the underside of seedling leaves and around the growing point.

Aphids are often associated with ants, which feed on a sugary substance (honeydew) produced by the aphids. In return, the ants protect the aphids.

Hosts: A wide range of plants including capsicum, eggplant and okra.

Damage: When there are too many aphids on a plant, they may remove large quantities of sap through sucking, causing leaf curl, and death of shoots.

Control:

- Protect natural enemies such as ladybird beetles. You could collect and introduce them in your nursery.
- Wash aphids off plants with water from a hose-pipe or watering can. This must be done frequently (3 times a week) to achieve good control. Be careful to not damage the seedlings.
- Use water mixed with a little quantity of dishwashing soap or detergent to spray aphids.
- Where seedling containers are placed on raised platforms, place the legs of the platforms inside bowls of water to which a little household detergent has been added, to prevent ants from reaching the aphids.

d) Whiteflies

These are very small white winged insects that are often present on a wide range of nursery plants including cabbage, tomato, eggplant and capsicum.

Damage: Damage is by sucking plant sap, which can seriously weaken plants. Under heavy infestation leaves may turn yellow, appear dry and drop prematurely. They may transmit plant viruses.

Control:

- Encourage natural enemies
- Use coloured sticky traps to control light infestations.

[Make a trap, 12-by-6 inches, from cardboard or strong poster board and paint it bright yellow. Then coat it with a sticky substance, such as petroleum jelly, petroleum jelly/mineral oil mix, mineral oil or heavy-grade motor oil (SAE 90). Hang the trap vertically or support it on stakes just above the plants. The adults are attracted to the yellow colour and become trapped on the sticky substance (Barrett, date unknown)].

- Use natural pesticides such as neem products.

e) Leaf-eating insects

Leaf-eating insects such as various beetles and caterpillars sometimes damage seedlings. Cutworms may also be a problem in seedbeds in some areas. Cutworms are night-feeding caterpillars which are not readily seen because they are hidden in the soil during daytime. However, their presence is easily recognisable by the presence of severed seedling tops lying next to their stumps.

<u>Control</u>

- Encourage natural enemies.
- Inspect plants regularly and destroy pest insects as soon as they are observed.
- Dust plants with wood ash to discourage the insects (although watering and rainfall will reduce effectiveness).
- Biological insecticides such as formulations of *Bacillus thuringiensis* or other suitable insecticides may be applied to control serious infestations of leaf-eating caterpillars.
- Use commercial cutworm baits if cutworm problem is severe.

g) Snails & slugs

<u>Hosts</u>: Almost all vegetable seedlings are vulnerable. They feed at night and hide during the day, and are favoured by damp environment.

Damage: They eat leaves and soft stems of seedlings. The presence of snails and slugs can be easily detected from their slime trails on the ground and debris.

Control:

- Inspect nursery early in the morning or late in the evening, or during the day on drizzly days; handpick and destroy them.
- Create bare ground around the nursery to reduce the number of snails that come into the nursery area.

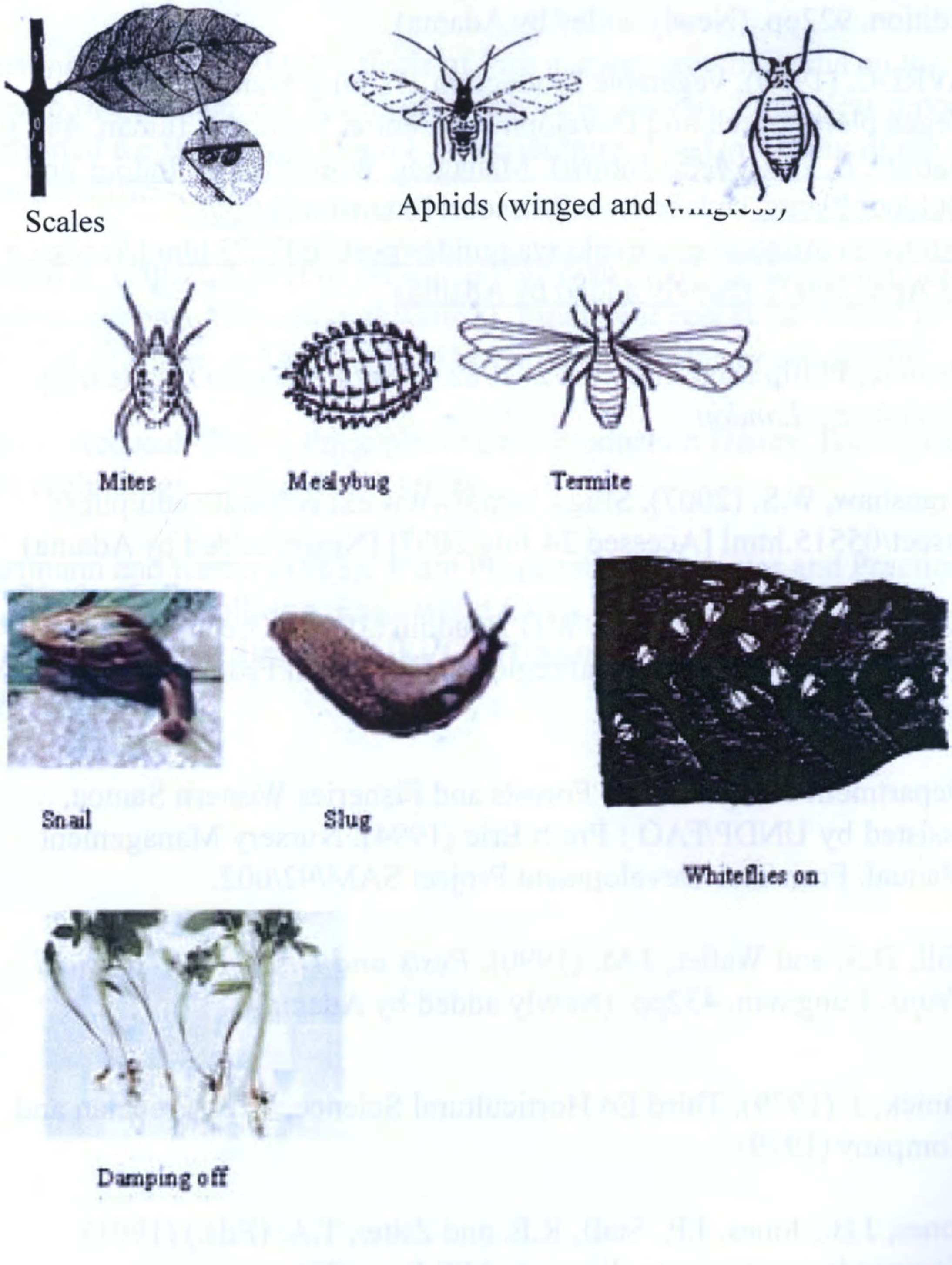
- If possible, apply wood ash regularly around vulnerable plants to deter snails and slugs.
- Keep the nursery environment free of hiding and breeding places by removing all non-essential materials (e.g. empty pots, cans, stones, bricks, sacks, etc.) and debris. However, you may deliberately place shelters (e.g. boards or rocks) around the nursery with the aim of attracting and destroying the pests. Inspect the shelters every morning.
- Do not use organic mulches (e.g. straw, leaves, grass clippings) where snails and slugs are a problem.
- Apply metaldehyde baits around the nursery during high infestations.

g) Birds

Damage: Sometimes birds cause problems in vegetable nurseries by digging out and eating seeds or very young seedlings. Total destruction is possible if not controlled.

Control: Make nursery in protected area. Cover seedbed with garden net. Erect scare-crows or other scaring devices, although birds may get used to them.

Figure 2: Common pest problems in plant nurseries. (Hill and Waller, 1988)



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